Cellular Automata and their Applications: A Review

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ABSTRACT
In this paper author reports a detail study on the convergence of the one-dimensional two-state 3 neighborhood asynchronous cellular automata (ACA) under null theory.

General Terms
Asynchronous Cellular automata (ACA), Classification

Keywords
Convergence, fixed point attractor, multi-state attractor

1. INTRODUCTION
Cellular Automata (CAs) are among the oldest model of natural computing, dating back over a half century. The journey of cellular automata were originally proposed by Jon Von Neumann in the late 19400 s as formal models of biological self-reproduction, the goal was to design self-replicating artificial systems that are also computationally universal. The framework studied was mostly based on one and two dimensional infinite grids though higher dimensions were also considered. At the beginning, CAs were only focus on the concept of computer science and mathematics. However, gradually it is used in different fields such as Physics, Biology etc. In the present era, CAs are being studied from many widely different fields, and the relationship of these structures to existing problems are being constantly sought and discovered. A Cellular Automaton (CA) is a discrete dynamic system comprising of an orderly network of cell, where each cell is a finite state automaton. The next state of a particular cell is decided by its previous state and its neighbor's (left and Right most neighbor's) cells following a local update rule. Wolfram in [52] said that CA is an infinite 1-Dimensional, where each square box called a cell. In CA there are two possible state 1 and 0, where 1 is considered as black cell and 0 is considered as white cell. The next of each cell depends on the state of itself and its two neighbours (left and right). The CA cannot only model biological self-reproduction but also computationally universal. The beauty of a CA is simple local interaction and computation of cell results in a huge complex behaviour when the cells add together. Since the inception, CAs have captured the attention of a large number of researchers already working in this field as well as new entrants to this field. There are different variations of CAs which have been suggested by different authors to ease the design and modelling of Complex Systems. They are LinearCA, Complement CA, Additive CA, Uniform CA, Hybrid CA, Null Boundary CA, Periodic Boundary CA, Programmable CA, Reversible CA, Non-Linear CA, Generalized Multiple Attractor CA, Fuzzy CA.

Cellular automata are a collection of cells that each consists of a finite num- ber of states. Single cells change in states by following a local rule that depends on the environment (i.e., neighbor's) of the cell. The environment of a cell is usually taken to be a small number of neighbouring cells i.e., 1 or 2 neighbor's for 1-Dimensional as well as 2-Dimensional CAs [19]. Fig. 1. shows two typical neighbourhood options i.e., for 1-Dimension as well as 2-Dimension, (a) One Way CA (b) Two Way CA are 1-Dimensional CAs and (c) Von Neumann Neighbourhood (d) Moore Neighbourhood are 2-dimensional CAs. Basically, a cellular automaton (CA) consists of a graph where each node is a finite state automaton (FSA) or cell. This graph is usually in the form of a two dimensional lattice whose cells evolve according to a global update rule (CA Rule) applied uniformly over all the cells. As arguments, this update rule takes the cells present state and the states of the cells in its interaction neighbourhood (left and right most cells) [8] as shown in Fig. 2.

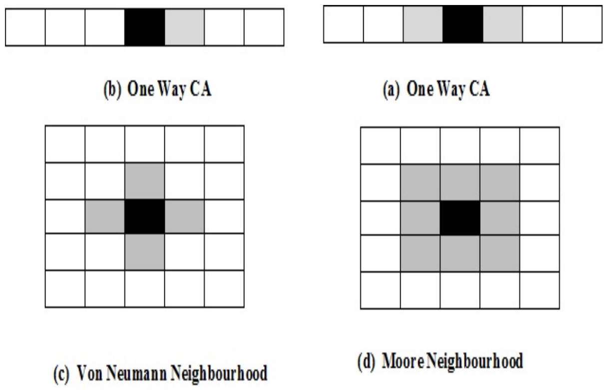

Fig. 1. 1(a) and 1(b) are 1-dimensional CAs, and 1(c) and 1(d) are 2-dimensional CAs

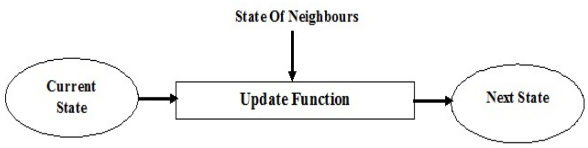

Fig. 2. State Transition depends on neighbourhood States.

Over the years, the computational model of CAs has been suggested to study the general phenomenological aspects including Communication, Construction, Growth, Reproduction, Competition and Evolution [22]. In the rest of this Paper we have discussed CA applied in different applications such as Image Processing, Fractals, Pattern Recognition and classification, Bio-Informatics, VLSI, Cryptography, The Games of life, Economic Systems, Biological Systems, Environ- mental Systems, Ecological Systems, Edge Detection, Traffic Systems, MachineLearning and Control, Crystallization Process and the like. In CAs [40][50], are defined by a lattice of cells and a local rule by